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(54) Crystalline alumina orthodontic bracket

Orthodontisches Bracket aus kristallinem Aluminiumoxid

Bracket orthodontique en alumine cristalline

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(56) References cited:

US-A- 2 045 025	US-A- 3 625 740
US-A- 3 764 507	US-A- 3 975 824
US-A- 4 122 605	US-A- 4 216 583
US-A- 4 219 617	US-A- 4 302 532
US-A- 4 322 206	US-A- 4 415 330

EP 0 161 831 B1

Description

The invention relates to an orthodontic bracket comprising as a load bearing member essentially monocrystalline alumina material such as essentially monocrystalline alpha-alumina.

Orthodontic brackets attach directly to teeth and serve to transmit corrective forces from an orthodontic archwire to the tooth to which the bracket is attached. The requirements for an orthodontic bracket are quite severe. First, it must have sufficient mechanical strength to withstand the forces to which it will be subjected, including the forces transmitted by an archwire, ligation forces, and mastication forces. Second, it must be chemically inert in the oral environment so that it will not corrode and will be and remain biologically inert. The bracket must meet these requirements, and still remain small enough to fit on the tooth. Despite proposals for making orthodontic brackets from many different materials, the overwhelming majority of othodontic brackets in use today are made of metal, usually stainless steel. Metal brackets meet all of the essential requirements, but they have one undesirable attribute - they are unsightly. A person undergoing orthodontic treatment has a conspicuous amount of metal in full view on the front surfaces of his or her teeth. Since the treatment extends over a number of years, this unsightly appearance must be endured for a considerable period of time.

The incentive to make brackets from less unsightly materials has existed for many years. But recently, orthodontic treatment has been given to increasing numbers of adults, for whom the unsightly appearance of metal brackets is more than a mere annoyance. Therefore, the incentive to provide more esthetic orthodontic treatment is even greater now than it has ever been.

To avoid the unsightly appearance of metal orthodontic brackets, it is now possible in some (but not all) cases to install the brackets and archwire on the lingual (tongue) side of the teeth. However, the lingual side technique usually takes much longer than the customary buccal side technique to complete the treatment. Also, the brackets and archwire sometimes interfere with the tongue during speech. It has been proposed to make orthodontic brackets out of less unsightly material, such as transparent or translucent plastic (e.g., polycarbonate), or ceramic materials which more closely resemble natural dentition. A problem with both plastic materials and ceramics is that their mechanical strengths are borderline, and bracket breakage can be a significant problem with them. The ceramic brackets that are currently in use are rather bulky (to overcome the physical property limitations of the material), so they tend to be somewhat uncomfortable to the patient. From an esthetic viewpoint, neither plastic nor ceramic are fully satisfactory either, because plastic may discolor (from coffee or tobacco, for example), and the color of ceramic rarely matches natural dentition. In an effort to overcome the strength limitations of ceramic and plastic brackets, it has been proposed to reinforce such brackets with metal inserts or metal liners (for the archwire groove). While this may help (although it will not fully alleviate) the strength limitations of plastic or ceramic brackets, such solutions bring back, to at least a limited degree, the esthetic problem for which the plastic or ceramic bracket was the proposed solution. Thus, to date, there is no really satisfactory solution to the problem of unsightly metal orthodontic brackets.

The invention provides an orthodontic bracket comprising as a load bearing member essentially monocrystalline alumina.

The bracket may be made entirely of essentially monocrystalline alumina. Alternatively the bracket may comprise a base member for attaching to a tooth, a body member extending from the base member, said body member including walls defining an archwire groove, wherein said walls comprise essentially monocrystalline alumina. The base member may be made of transparent plastic material and the body member may be entirely essentially monocrystalline alumina.

In a further alternative, the bracket comprises a transparent plastic bracket having an archwire groove lined with essentially monocrystalline alumina.

The present invention also provides an essentially monocrystalline alumina orthodontic bracket comprising a base member including a surface intended for adhesive contact with a tooth, and a body member extending from said base member, wherein said surface includes an undercut portion for enhancing the mechanical adhesion of said surface to an orthodontic cement.

Preferably, the essentially monocrystalline alumina is crystalline alpha-alumina, and advantageously the essentially monocrystalline alumina has a modulus of rupture greater than 35,000 psi (241.3 MPa).

The strength and transparency properties of alpha-alumina and certain other essentially monocrystalline alumina materials permit the provision of orthodontic brackets that are much more esthetic than metal brackets, but which alleviate to a large degree the strength limitations of plastic and ceramic brackets.

High alumina content, injection molded, randomly oriented, polycrystalline ceramic orthodontic brackets are disclosed by Reynolds in U.S. Patent Nos. 4,216,583 and 4,322,206, and by Wallshein in U.S. Patent No. 4,219,617. In order to enhance adhesion to the tooth, Reynolds mentions the possibility of providing an undercut portion in an aperture in the tooth contacting surface of his bracket. However, such undercut portion would have to be machined, at prohibitive expense, since it is impossible to mold it. The commercial version of the Reynolds bracket lacks the undercut portion.

Plastic orthodontic brackets containing metal reinforcement and/or metal liners for the archwire groove are disclosed by Andrews in U.S. Patent No. 3,930,311, Stahl in U.S. Patent No. 3,964,165, Kurz in U.S. Patent No. 4,107,844, Frantz in U.S. Patent No. 4,299,569, and Wallshein in U.S. Patent No. 4,302,532.

Hirabayashi et al., in U.S. Patent No. 4,122,605, disclose a somatic element made of single crystalline sap-

phire. Specific elements disclosed include a screw type implant pin, a blade type implant pin, a pin type implant pin, and a compression plate.

Richardson, in U.S. Patent No. 2,045,025, discloses a method for making orthodontic band brackets (i.e., the brackets that are attached to tooth engaging bands) wherein a longitudinal slot is cut in a bar of metal to form a bar that has a desired cross-sectional configuration, followed by cutting blanks from the bar and then machining the blanks to form the brackets.

The semi-conductor art has disclosed articles made of single crystal alumina having a coating of silica. For instance, see McKinnon et al., U.S. Patent No. 3,764,507.

Hurley, in U.S. Patent No. 3,625,740, discloses a process for treating a crystalline alpha-alumina surface with a silane to enhance adhesion to an epoxy resin.

Daisley et al., in U.S. Patent No. 4,415,330, disclose an orthodontic bracket having a generally rhomboidal configuration.

In the accompanying drawings:

Fig. 1 is a perspective view of an orthodontic bracket made of essentially monocrystalline alpha-alumina;

Fig. 2 is a side view of the bracket of Fig. 1;

Fig. 3 is a front view of the bracket of Fig. 1;

Fig. 4 is a top view of the bracket of Fig. 1;

Fig. 5 is a top view of a die that is used to produce an essentially monocrystalline alpha-alumina rod having a cross-sectional configuration essentially identical to the configuration of the top of said die;

Fig. 6 is a schematic representation of apparatus for producing an essentially monocrystalline alpha-alumina rod;

Fig. 7 is a perspective view of an essentially monocrystalline alpha-alumina rod produced by the apparatus of Fig. 6;

Fig. 8 is a perspective view of a bracket blank cut from the essentially monocrystalline alpha-alumina rod of Fig. 7;

Fig. 9 is a schematic representation of apparatus for sputter coating silica on an essentially monocrystalline alpha-alumina article;

Fig. 10 is a perspective view of a plastic orthodontic bracket having an essentially monocrystalline alpha-alumina liner in the archwire groove;

Fig. 11 is a perspective view of an orthodontic bracket having a plastic base, with the remainder of the bracket being essentially monocrystalline alpha-alumina;

Fig. 12 is a view similar to Fig. 5, showing an alternative configuration of the top of the die;

Fig. 13 is a perspective view of an essentially monocrystalline alpha-alumina orthodontic bracket having a keyway in the base for the purpose of enhancing the bonding of the bracket to the tooth;

Fig. 14 is a side view of the orthodontic bracket of Fig. 13;

Fig. 15 is a perspective view of a "single-wing" orthodontic bracket made of essentially monocrystalline alpha-alumina;

Fig. 16 is a perspective view of an alternate essentially monocrystalline alpha-alumina rod that can be produced by the apparatus of Fig. 6;

Fig. 17 is a perspective view of a series of bracket blanks as they are cut from the rod of Fig. 16;

Fig. 18 is a top plan view of the blanks of Fig. 17;

Fig. 19 is a top view of a die that is used to produce the rod of Fig. 16;

Fig. 20 is a perspective view of an orthodontic bracket machined from the blanks of Figs. 17 and 18; and

Fig. 21 is a front view of the bracket of Fig. 20.

This invention is directed to the provision of orthodontic brackets comprising as a load bearing member essentially monocrystalline alumina materials, preferably essentially monocrystalline alpha-alumina.

Essentially monocrystalline alumina is comprised of a single crystal or two or more single crystals grown together longitudinally but separated by a relatively small angle (usually within 4°, determined with respect to the C-axes of neighboring single crystals) grain boundary.

In a preferred aspect of the invention, the orthodontic bracket is entirely essentially monocrystalline alpha-alumina. Such a bracket can be produced by first drawing an essentially monocrystalline alpha-alumina rod from a melt, wherein the rod has a predetermined cross-sectional configuration, by slicing the rod into individual blanks, and then machining the blanks to produce the bracket. A detailed description of this process follows.

The preferred procedure for producing an essentially monocrystalline alpha-alumina rod having a predetermined cross-sectional configuration is the EFG (for Edge-defined, Film-fed, Growth) modification of the Czochralski process for growing crystalline alpha-alumina. The EFG process is described by LaBelle in "EFG - The

Invention and Application to Sapphire Growth", in Journal of Crystal Growth, 50, pages 8-17 (September 1980). See also LaBelle, U.S. Patent No. 3,591,348, LaBelle et al., U.S. Patent Nos. 3,701,636 and 3,915,662, and other patents and articles cited in the Journal of Crystal Growth article.

Fig. 6 is a schematic representation of apparatus for producing an essentially monocrystalline alpha-alumina rod having a predetermined cross-sectional configuration by the EFG process. The apparatus 20 includes a crucible 22 containing molten alumina 24. A die 26 made of a suitable material such as molybdenum or iridium is positioned such that the bottom of the die 26 is immersed in the molten alumina 24, and the top of the die 26 is above the surface of the melt 24. A vertical distance from the top of the melt 24 to the top surface 28 of the die 26 of up to 50 millimeters is permissible. (This distance is exaggerated in Fig. 6 for clarity.)

Fig. 5 shows the top surface 28 of the die 26. The top surface 28 is smooth, flat, and has the shape of the desired configuration of the cross-section of the essentially monocrystalline alpha-alumina rod 30 (shown in Fig. 7) from which the brackets are made. It is important that the sides 32 and the top surface 28 of the die 26 meet in a sharp 90° angle, in order to minimize imperfections in the surface of the growing rod 30. The die 26 contains a capillary passage 34 through which molten alumina 24 is drawn. The melt 24 is drawn from the crucible 22 through the capillary 34 to the top surface 28 of the die 26, where it spreads out and completely covers the said top surface 28 with a film of molten alumina. However, because molten alumina and molybdenum or iridium have the appropriate wettability relationship, the molten alumina film stops at the edge of the surface 28. Therefore, essentially monocrystalline alpha-alumina crystal grown or pulled from this film of molten alumina assumes a cross-sectional configuration substantially exactly the same as the configuration of the top surface 28 of the die 26. Thus, the rod 30 (which had been started by a seed crystal, as in the Czochralski process) pulled by a pulling mechanism 36 from the film of molten alumina on the top surface 28 of the die 26 will have a cross-sectional configuration substantially identical to the configuration of the top surface 28 of the die 26. It has been found to be convenient to grow the rod 30 to a length of about two inches (about 5 centimeters) in order to minimize any machining problems that could be caused by the failure of the rod to grow exactly straight.

The crystal orientation of the growing rod may prove to be important (at least economically, and perhaps also from a performance standpoint) in the practice of the invention. In the case of essentially monocrystalline alpha-alumina, the crystal orientation can be defined with reference to the C axis of the crystal. (The C axis is perpendicular to the plane which contains the simplest arrangement of atoms in the crystal unit cell. Stated another way, the C axis is perpendicular to the plane which contains the a_1 and a_2 axes.) The minimum amount of strain developed in the growing crystal will occur if the C axis is found in a plane perpendicular to the longitudinal axis L of the rod 30. (See Fig. 7.) This has proven to be the optimum crystal orientation in some cases. (As is known in the art, the growing crystal will assume the crystal orientation of the seed crystal.)

Regardless of the crystal orientation of the rod 30, it is preferred to anneal the rod 30 prior to machining so as to relieve stresses in the crystal to minimize the chances of breakage during machining. A typical annealing cycle would be to heat the rod 30 from room temperature up to 18 50°C at an even rate for about 12 hours, to maintain the rod 30 at 1850°C for 4 to 6 hours, and to then cool the rod 30 down to room temperature at an even rate for 18 to 24 hours.

The essentially monocrystalline alpha-alumina rod 30 is cut into individual blanks 38 (Fig. 8), each of which is machined into a bracket. Figs. 1-4 are various views of an orthodontic bracket 40 made completely of essentially monocrystalline alpha-alumina. The bracket 40 is made from the blank 38 by a series of cutting, grinding, and polishing steps, using known techniques for machining essentially monocrystalline alpha-alumina. A diamond cutting wheel may be used to cut out the archwire groove 42 and the "saddle" 43 of a double wing bracket (such as is shown in Fig. 1). A single wing bracket 41 is shown in Fig. 15. Edges may be beveled by grinding, and corners rounded off by polishing.

A convenient procedure for fabricating the bracket from the essentially monocrystalline alpha-alumina rod 30 is the following:

The rod 30 is fastened to a rod holding fixture (not shown) with the base surface 71 facing out. The base surface 71 is then ground to an arcuate concavity with a diamond grinding wheel. This concavity is shown as 74 in Figs. 1, 2, and 8.

After the bases have been ground to produce the concavity 74, the rods may be reversed in the fixtures and the top surfaces 75 may be ground to compensate for any dimensional differences arising from the crystal growing process. This ensures a precisely controlled base to top dimension.

The rods, with the bases and tops ground, may then be cut into blanks 38 (Fig. 8) with a diamond saw (not shown) by making cuts in a plane perpendicular to the longitudinal axis L of the rod 30.

The archwire groove 42 and the saddle 43 are then ground with a diamond grinding wheel. It is preferred to grind the archwire groove in two passes. For instance, if the desired archwire groove is 20 mils (508 μm) wide and 30 mils (762 μm) deep, the first pass will typically move enough material to make a groove 15 mils (381 μm) wide and 20 mils (508 μm) deep. Following this procedure helps to minimize imperfections in the finished bracket.

A second arcuate concavity, shown as 73 in Figs. 1 and 4, is then ground in the base or tooth contacting surface using a diamond grinding wheel. The arcuate concavities 73 and 74 are employed so that the contour of the base more nearly matches the surface contours of a tooth.

In an alternative embodiment of the invention, the archwire groove may be "grown" into the rod. This aspect is illustrated in Figs. 16-21. By using a die 80 (Fig. 19) whose top surface 82 has a slot 84, a rod 86 can be grown having a longitudinal groove 88 in it so that, when the individual brackets are cut from the rod 86, the brackets will already have the archwire groove 90. By so doing, one step (i.e., the grinding of the archwire groove) in the procedure for producing the bracket can be eliminated, at a significant cost saving.

One difference in the procedure for making the brackets in accordance with this alternative embodiment of the invention is that the bracket blanks 92 that are cut from the rod 86 are cut at a slight angle. Thus, instead of making the cuts in the rod 86 in a plane normal or perpendicular to the longitudinal axis L of the rod, the cuts are made in the following manner:
Holding the rod 86 in position with the longitudinal axis L in a horizontal plane and the face having the groove 88 on top, each cut is made in a vertical plane that is angled slightly (e.g., up to about 12°) at an angle α from the vertical plane that is perpendicular to the longitudinal axis L of the rod 86. This is best seen in Fig. 18.

In one alternative procedure, the saddles and the second base concavities 73 can be machined in the bracket prior to cutting the individual brackets from the rod 86. This is preferred because it is easier to handle the rod 86 than the individual bracket blanks 92.

Figs. 20 and 21 are perspective and front views, respectively, of a bracket 94 made from the blank 92.

After machining, the brackets are preferably annealed under the conditions disclosed above for drawn rods. Then, the brackets are preferably polished to smooth off contours and to remove any surface imperfections which could encourage propagation of cracks. A flux polishing procedure is recommended, in which the flux is partially saturated with alumina so that the removal of alumina from the surface of the bracket will proceed at a controllable rate. One preferred flux is composed of 51.2 per cent $LiBO_2$, 12.8 per cent $Li_2B_4O_7$, 16 per cent Al_2O_3, and 20 per cent LiF (the percentages are by weight). The machined brackets are immersed in molten flux at 850° to 900°C for a few minutes, e.g. from about four to about thirty minutes, and then removed. After cooling, the brackets can be immersed in aqueous hydrofluoric acid to remove any flux adhering to the surfaces of the brackets.

Other processes for polishing the surface of essentially monocrystalline alpha-alumina objects are known, and may be used if desired. Such other processes are disclosed, for example, by Noble, in U.S. Patent No. 4,339,300, and Manasevit, in U.S. Patent No. 3,546,036.

In alternative embodiments of the invention, the most critical load bearing portions of the bracket are made of essentially monocrystalline alumina material, while the remainder is made of another transparent material, such as polycarbonate or polysulfone plastic, that is less expensive, easier to work, and easier to bond to the tooth. Fig. 10 shows one such alternative embodiment, wherein the bracket 44 is made predominantly of transparent plastic 46 (e.g. polycarbonate), but wherein the archwire groove has an essentially monocrystalline alumina liner 48 cemented therein. In another embodiment, shown in Fig. 11, the bracket 50 has a transparent plastic base 52 (as the tooth contacting portion) cemented to an essentially monocrystalline alumina body 54. In both of these alternative embodiments, the essentially monocrystalline alumina portions can be made by a modification of the method described above, starting with an essentially monocrystalline alumina rod of appropriate shape made by the EFG process.

Bonding an essentially monocrystalline alumina bracket to the tooth (or to a plastic base or to any other substrate) must be done with care. Many of the ordinary orthodontic cements (which are usually acrylic resins) will not adhere well to essentially monocrystalline alumina without taking steps to enhance the adhesion. One means of enhancing the adhesion of an essentially monocrystalline alumina bracket to the tooth is illustrated in Figs. 13 and 14, in which a bracket 56 is shown that has an undercut or keyway 58 in the bottom or tooth-contacting surface of the bracket 56. Orthodontic cement filling the keyway 58 will have enhanced mechanical adhesion to the bracket 56 because of the undercut portion. This bracket 56 can be made by a method analogous to that described above, starting with the EFG process using a molybdenum die 60 having a top surface 28a shaped as shown in Fig. 12.

Another means of enhancing the adhesion of cements such as acrylic resins to an essentially monocrystalline alumina bracket is to alter the surface of the essentially monocrystalline alumina in such a way as to increase the strength of the adhesive bond between the essentially monocrystalline alumina and the cement. It is known, for instance, that a wide variety of silicone coupling agents can be used to enhance the adhesive force between siliceous substrates and a wide variety of thermosetting plastics. This technology may be utilized by coating the essentially monocrystalline alumina surface that is to be in contact with the cement with a thin coating (usually thinner than about 10,000 angstroms (1 µm), and preferably, up to about 1,000 angstroms (0.1 µm)) of a siliceous material such as silica, and then using silicone or silane coupling agents to enhance the bond of that surface to the cement, in a manner analogous to that which is presently known. Examples of means for coating the essentially monocrystalline alumina surface with a siliceous material are cathode sputtering, plasma deposition, and electron beam evaporation, all of which are known techniques, especially in the semi-conductor arts. Fig. 9 is a schematic representation of apparatus suitable for sputter coating silica onto the surface of an essentially monocrystalline alumina orthodontic bracket. The apparatus, shown generally as 62, includes a sputtering chamber 64 (which is vacuum tight), a target 66, in this case silicon metal, which is brought to cathode potential, an RF or DC power supply 68, and a plate 70 for holding the cleaned and dried substrate 72 to be coated, in which

the plate 70 is brought to anode potential. A source of oxygen (not shown) introduces oxygen into the chamber 64 so that the silicon metal 66 will be converted to silicon dioxide on the substrate 72. Reactive sputtering, such as is briefly outlined here, is known. For instance, see "The Basics of Sputtering", printed in December 1980 by Materials Research Corporation, Orangeburg, New York 10962.

The essentially monocrystalline alumina bracket having its base or tooth-contacting surface sputter coated with silica or other siliceous material such as a glass, has excellent affinity for silicone coupling agents such as A-174 (gammamethacryloxypropyltrimethoxysilane), and by using such coupling agents the adhesion of the bracket to acrylic orthodontic cements is enhanced. Before applying the coupling agent, the silica-coated bracket should be heated in air for about 1 hour at 350°C to convert the silica surface to a form that has a greater affinity for the coupling agent. For a fuller description of the use of a thin siliceous coating on the surface of essentially monocrystalline alumina to enhance the adhesive bond to cements, see our copending European application No. 0 160 481 entitled "Crystalline Alumina Composites", filed on April 22 1985.

Another method for enhancing the affinity of the essentially monocrystalline alpha-alumina bracket to silicone coupling agents is to heat the brackets to remove adsorbed water, and then treat the bracket with a dilute solution (e.g. a 2 to 2.5 weight per cent solution in toluene/propylene glycol mono-methyl ether) of a silane coupling agent such as A-174. A heat treatment in air at 350°C overnight (about 16 hours) has been found to be satisfactory. Alternatively, a short (about 1/2 hour) treatment in vacuum at 110°C followed by heating in air at 350°C for about three hours may be used. In both cases, the heat treated essentially monocrystalline alumina bracket should be protected from moisture prior to the silane treatment. After treatment with the silane, a post-cure at, e.g. 110°C for about 1 to 3 hours, is recommended to develop the optimum bonding strength.

The orthodontic brackets of the invention have enhanced esthetics because of the transparency of essentially monocrystalline alumina. For instance, the transparency of essentially monocrystalline alpha-alumina is such that a total of up to 98.5 per cent of light in the visible range is transmitted through it, as determined by the integrating sphere method.

The yield strength of the steel that is used to make orthodontic brackets is typically about 35,000 to 40,000 psi (241.3 to 275.8 MPa). The modulus of rupture of essentially monocrystalline alpha-alumina used in the invention is at least 35,000 to 40,000 (241.3 to 275.8), and is often as high as about 100,000 psi (689.5 MPa). Therefore, the effective strength of the brackets of the invention is at least as high as that of the usual steel bracket and often much higher, but with significantly enhanced esthetics. (The modulus of rupture is determined at 25°C by the test procedure of ASTM C-674.)

The invention has been described most particularly with respect to the use of essentially monocrystalline alpha-alumina (sapphire) as the material from which the subject orthodontic brackets are made. However, other essentially monocrystalline alumina materials can be used in the invention. The limiting requirements are adequate modulus of rupture (i.e. greater than the yield strength of the steel that is currently used for most orthodontic brackets), and sufficient transparency that the natural tooth color can be seen through the bracket. Other essentially monocrystalline alumina materials that can be used include yttrium aluminum garnet, magnesium aluminum spinel, and alpha-alumina in which a small percentage of the aluminum atoms has been replaced with other elements to impart color and/or fluorescence to the crystal. For instance, fluorescence can be imparted to the crystal by the addition of small amounts (e.g. less than 1 mole per cent) of terbium oxide or cerium oxide to the aluminum oxide.

Claims

1. An orthodontic bracket characterised in that it comprises as a load bearing member essentially monocrystalline alumina.

2. The orthodontic bracket of claim 1 wherein said bracket is made entirely of essentially monocrystalline alumina.

3. The orthodontic bracket of claim 1 comprising a base member for attaching to a tooth, a body member extending from the base member, said body member including walls defining an archwire groove, wherein said walls comprise essentially monocrystalline alumina.

4. The orthodontic bracket of claim 3 wherein said base member is made of transparent plastic material and said body member is entirely essentially monocrystalline alumina.

5. The orthodontic bracket of claim 3 comprising a transparent plastic bracket having an archwire groove lined with essentially monocrystalline alumina.

6. A essentially monocrystalline alumina orthodontic bracket comprising a base member including a surface intended for adhesive contact with a tooth, and a body member extending from said base member, wherein said surface includes an undercut portion for enhancing the mechanical adhesion of said surface to an orthodontic cement.

7. The orthodontic bracket of any one of claims 1 to 6 wherein the essentially monocrystalline alumina is crystalline alpha-alumina.

8. The orthodontic bracket of any one of claims 1 to 7 wherein the essentially monocrystalline alumina has a modulus or rupture greater than 35,000 psi (241.3 MPa).

Patentansprüche

1. Orthodontisches Bracket, dadurch gekennzeichnet, daß es als lasttragendes Element im wesentlichen monokristallines Aluminiumoxid umfaßt.

2. Orthodontisches Bracket gemäß Anspruch 1, wobei das Bracket ganz aus im wesentlichen monokristallinem Aluminiumoxid besteht.

3. Orthodontisches Bracket gemäß Anspruch 1, mit einem Basiselement zur Befestigung an einem Zahn, und einem von dem Basiselement ausgehenden Körperelement, das Wände umfaßt, die eine Bogendraht-Rille definieren, wobei die Wände im wesentlichen monokristallines Aluminiumoxid umfassen.

4. Orthodontisches Bracket gemäß Anspruch 3, wobei das Basiselement aus durchsichtigem Kunststoff besteht, und das Körperelement ganz aus im wesentlichen monokristallinem Aluminiumoxid besteht.

5. Orthodontisches Bracket gemäß Anspruch 3, das ein durchsichtiges Kunststoff-Bracket umfaßt, das eine mit im wesentlichen monokristallinem Aluminiumoxid überzogene Bogendraht-Rille hat.

6. Orthodontisches Bracket aus im wesentlichen monokristallinem Aluminiumoxid, mit einem Basiselement, das eine Oberfläche umfaßt, die für einen Haftkontakt mit einem Zahn bestimmt ist, und einem Körperelement, das von dem Basiselement ausgeht, wobei die Oberfläche einen unterschnittenen Bereich umfaßt, um die mechanische Haftung der Oberfläche an einem orthodontischen Zement zu vergrößern.

7. Orthodontisches Bracket gemäß irgendeinem der Ansprüche 1 bis 6, wobei das im wesentlichen monokristalline Aluminiumoxid kristallines Alpha-Aluminiumoxid ist.

8. Orthodontisches Bracket gemäß irgendeinem der Ansprüche 1 bis 7, wobei das im wesentlichen monokristalline Aluminiumoxid einen Bruchmodul von mehr als 241,3 MPa (35.000 psi) hat.

Revendications

1. Bracket orthodontique caractérisé en ce qu'il comprend un élément porteur essentiellement formé d'alumine monocristalline.

2. Bracket orthodontique selon la revendication 1, dans lequel ce bracket est totalement ou essentiellement formé d'alumine monocristalline.

3. Bracket orthodontique selon la revendication 1 comportant un élément de base destiné à la fixation sur une dent, un élément formant corps partant de l'élément de base, ledit élément formant corps comprenant des parois qui définissent une rainure pour le fil d'arcade, dans lequel lesdites parois sont essentiellement formées d'alumine monocristalline.

4. Bracket orthodontique selon la revendication 3, dans lequel ledit élément de base est constitué de matériau plastique transparent et ledit élément formant corps est entièrement formé d'alumine monocristalline.

5. Bracket orthodontique selon la revendication 3 comprenant un bracket plastique transparent comportant une rainure pour le fil d'arcade garnie d'alumine essentiellement monocristalline.

6. Bracket orthodontique en alumine essentiellement monocristalline comprenant un élément de base doté d'une surface destinée au contact par adhérence avec une dent, et un élément formant corps partant dudit élément de base, dans lequel ladite surface comprend une partie en contre-découpe destinée à améliorer l'adhérence mécanique de ladite surface à un ciment orthodontique.

7. Bracket orthodontique selon l'une quelconque des revendications 1 à 6 dans lequel l'alumine essentiellement monocristalline est de l'alumine alpha cristalline.

8. Bracket orthodontique selon l'une quelconque des revendications 1 à 7 dans lequel l'alumine essentiellement monocristalline a un module de rupture supérieur à 35.000 psi (241,3 mPa).

FIG-1

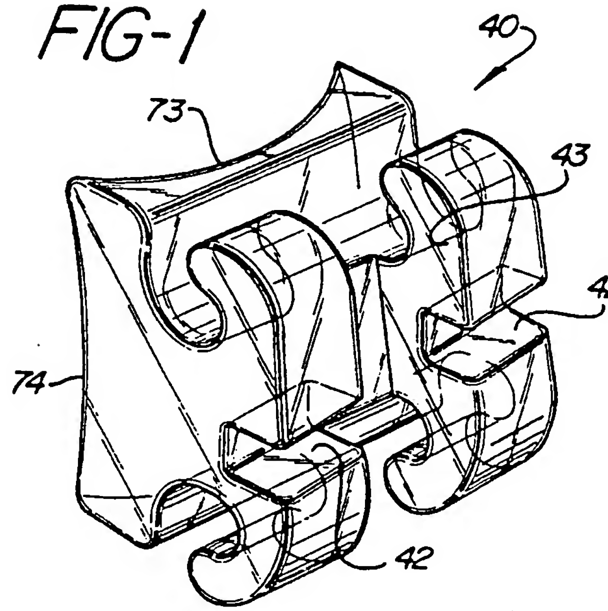


FIG-2

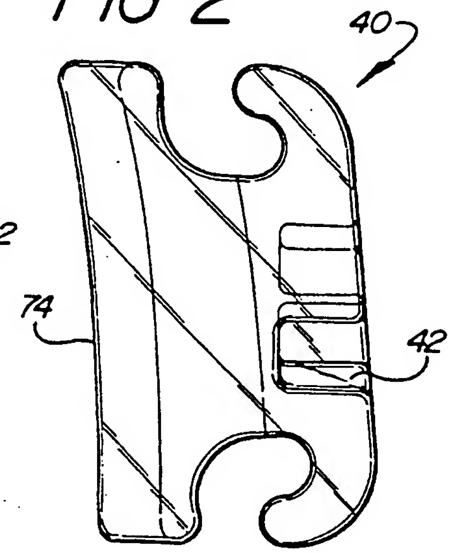


FIG-3

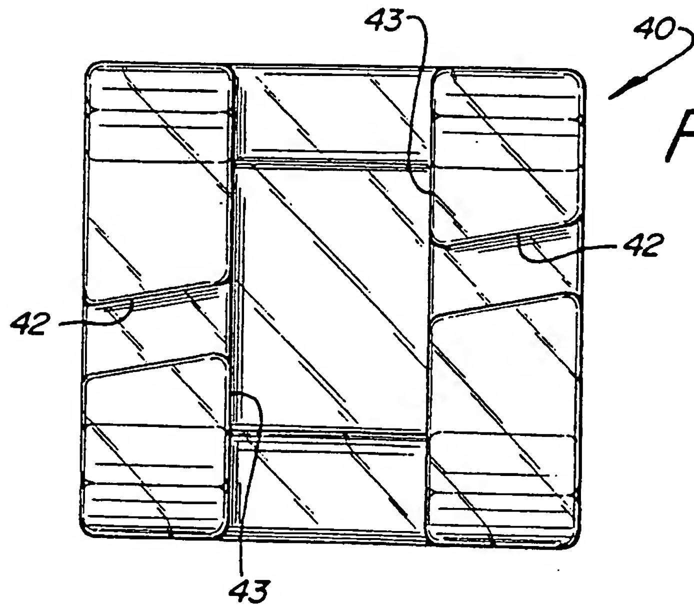


FIG-4

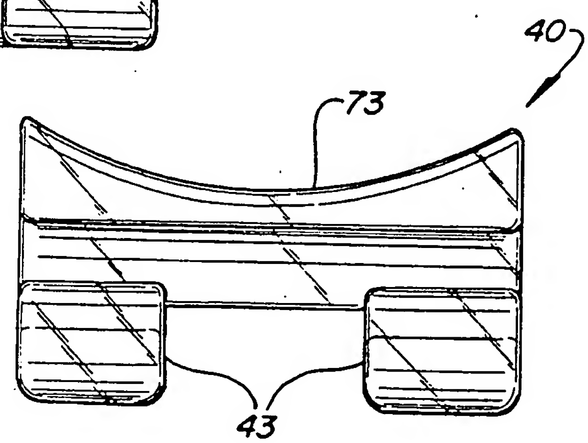
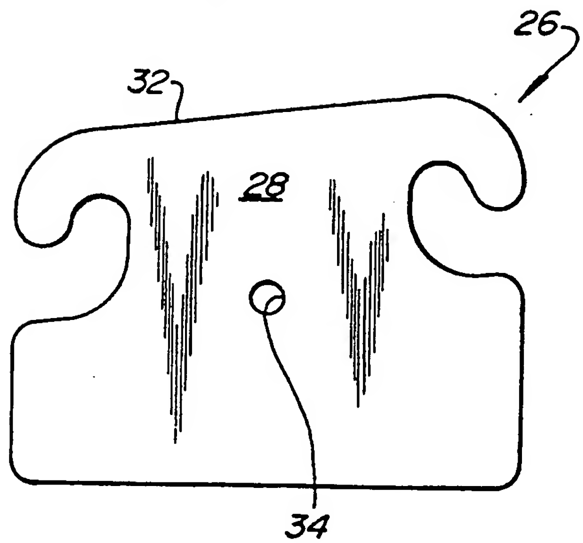


FIG-5



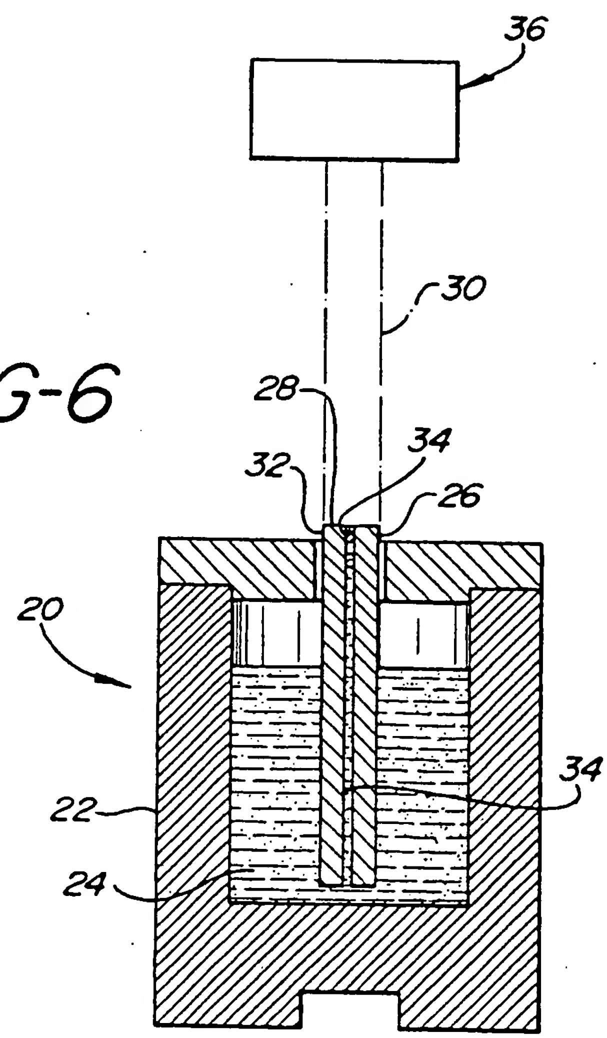


FIG-6

FIG-7

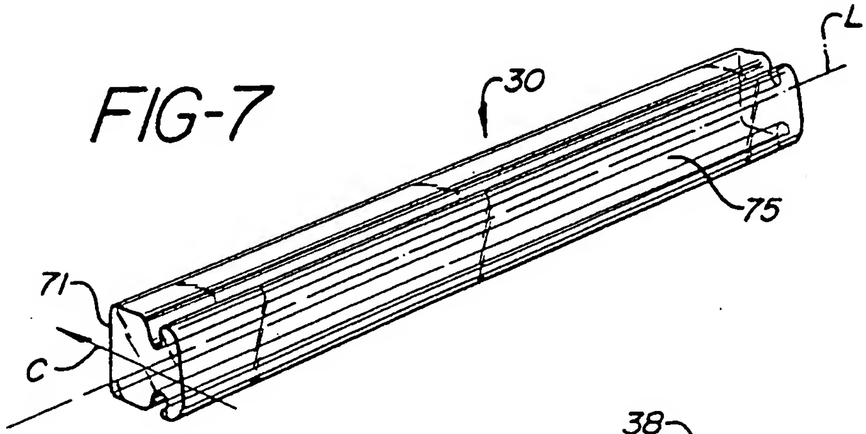


FIG-8

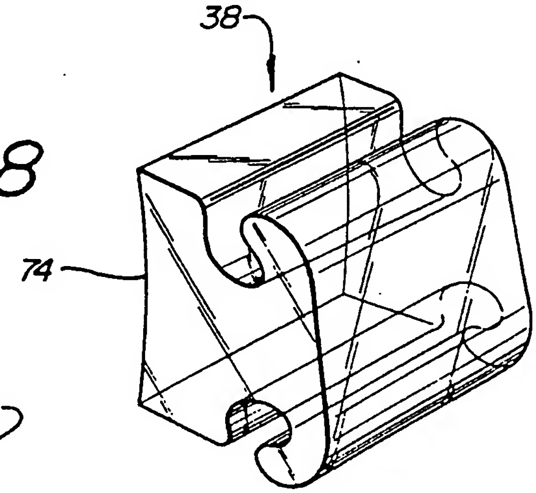
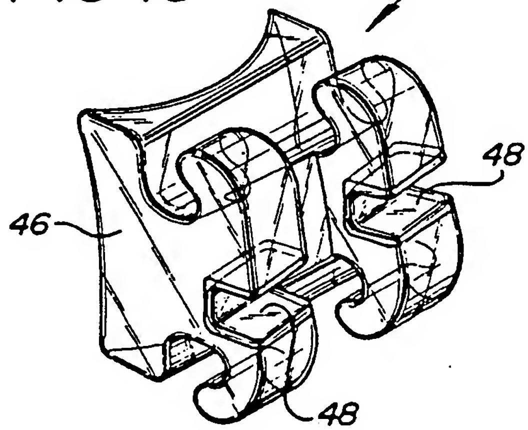


FIG-10



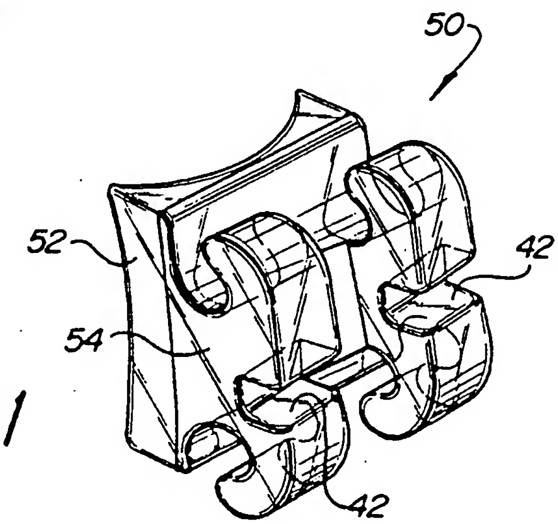


FIG-11

FIG-9

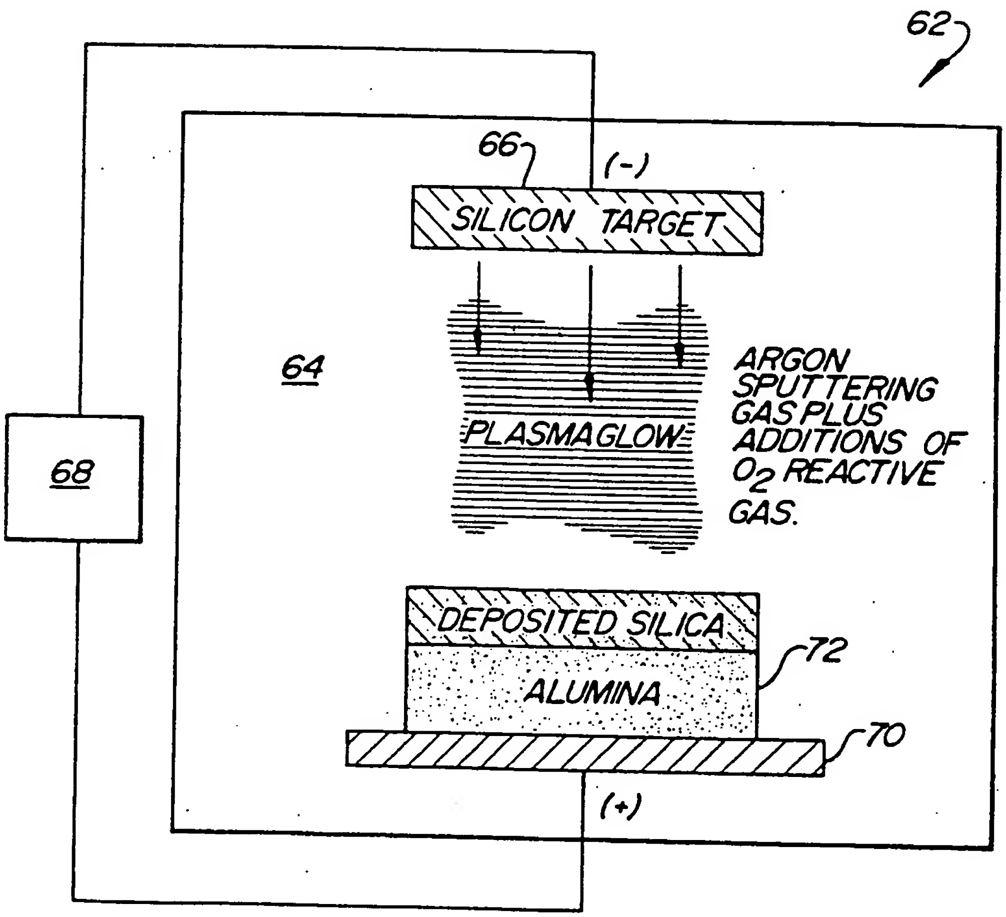

62
66
(-)
SILICON TARGET
64
68
PLASMAGLOW
ARGON SPUTTERING GAS PLUS ADDITIONS OF O_2 REACTIVE GAS.
DEPOSITED SILICA
72
ALUMINA
70
(+)

FIG-12

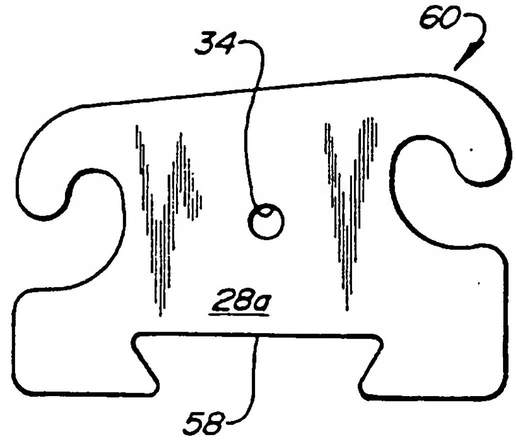


FIG-13

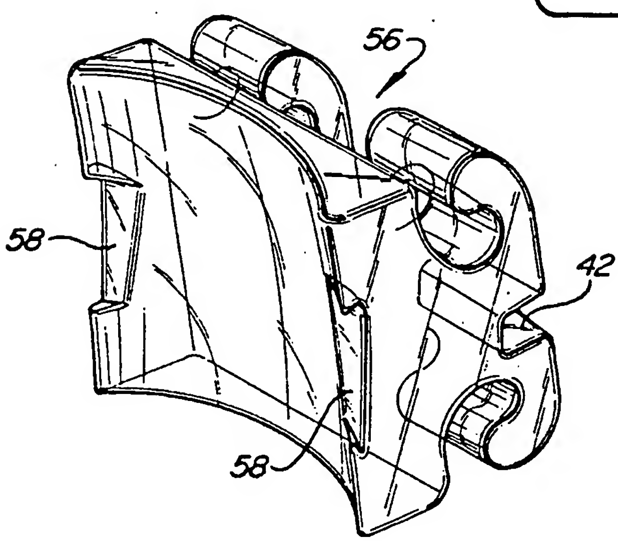


FIG-14

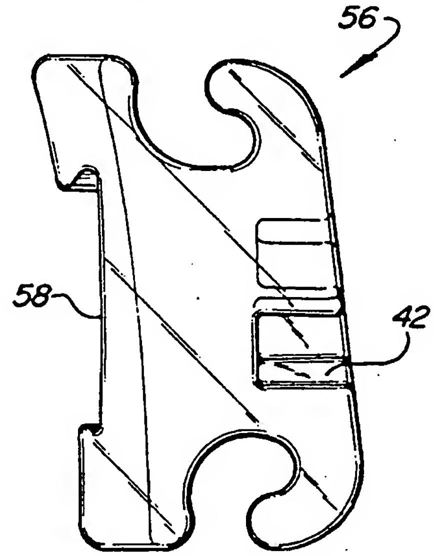


FIG-15

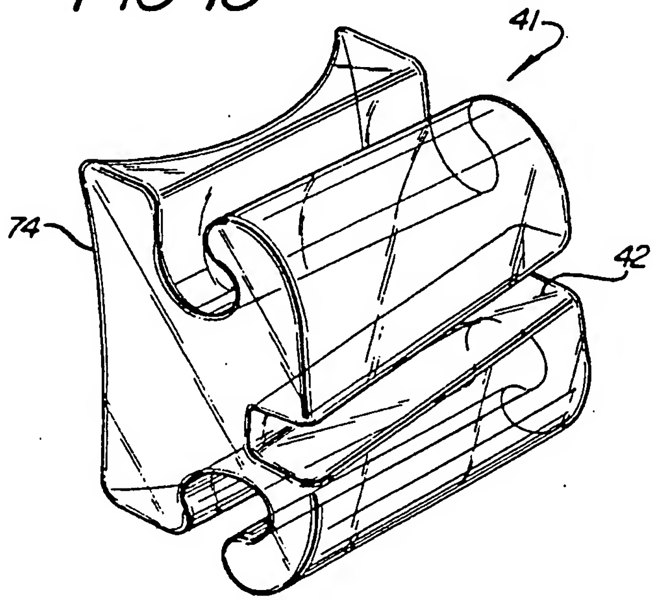


FIG-16

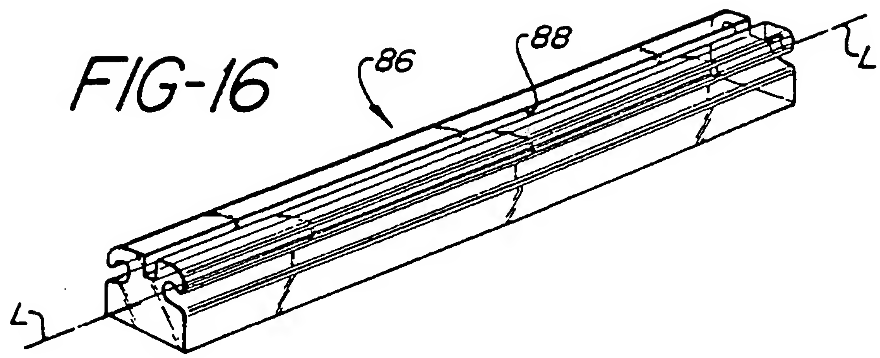
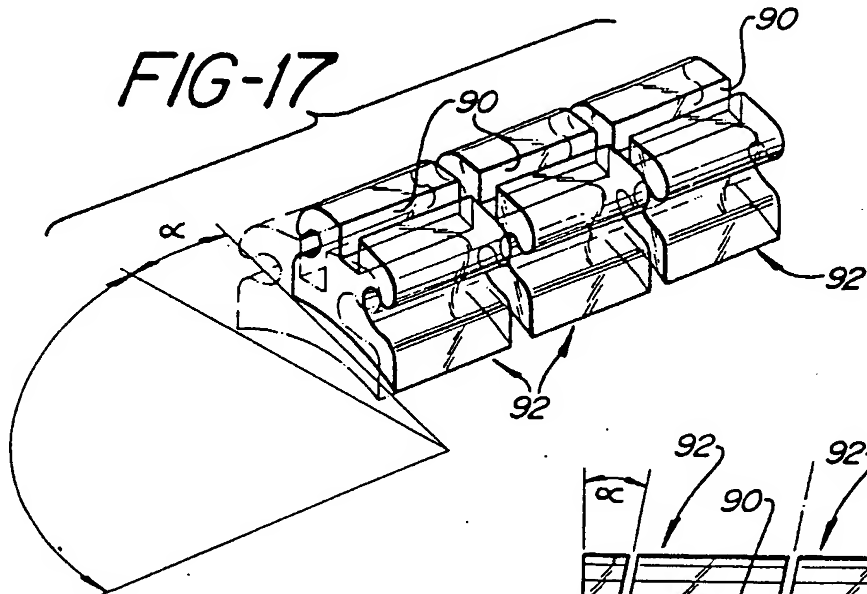


FIG-17



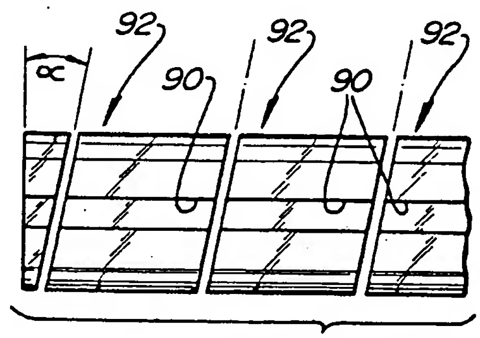


FIG-18

FIG-19

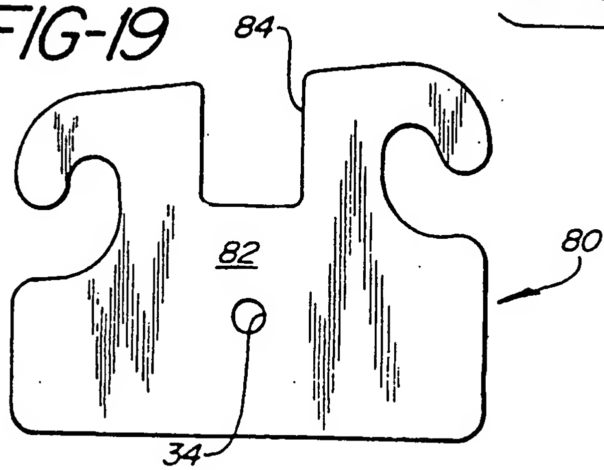


FIG-20

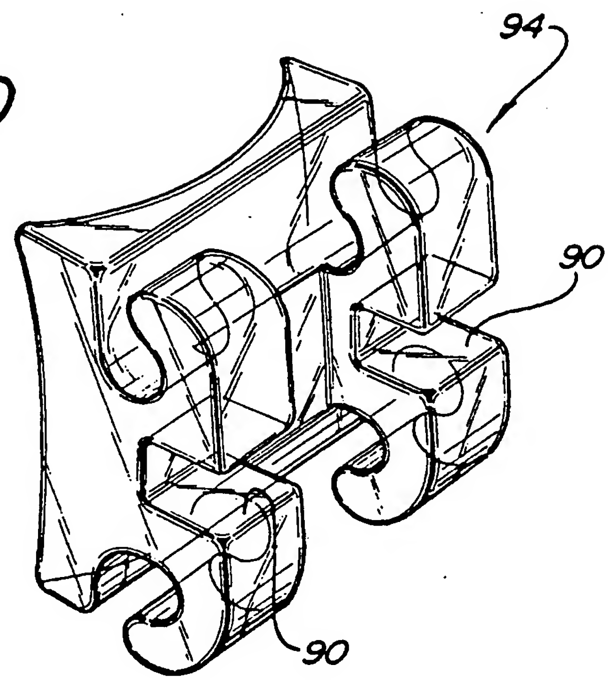


FIG-21